UCRL-ID-132615

Status Report: Stress Corrosion Cracking of Ni-Base and Ti Alloys

Ajit K. Roy

December 1, 1998

Lawrence Livermore National Laboratory

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (423) 576-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

OBS: 110 (WP #11017040M3
QA: L

Civilian Radioactive Waste Management System
Management & Operating Contractor

Status Report: Stress Corrosion Cracking of Ni-Base and Ti Alloys

Draft B

December 1998

Prepared for:

TRW Environmental Safety Systems Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134-6352

Prepared by:

Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, California 94551-0808

Under Memorandum Purchase Order
HD2979KR5X

Civilian Radioactive Waste Management System
Management & Operating Contractor

Status Report: Stress Corrosion Cracking of Ni-Base and Ti Alloys

Draft B

December 1998

Prepared by:

Name ______________________________ Date ____________

Name ______________________________ Date ____________

Approved by:

Name ______________________________ Date ____________

Name ______________________________ Date ____________

UCRL-ID-132615

Status Report:

Stress Corrosion Cracking of Ni-Base and Ti Alloys

WP267M4

by

Ajit K. Roy

December 1998

Lawrence Livermore National Laboratory
Livermore, California

This is an informal report intended primarily for internal distribution.
The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.
Work performed under the auspices of the Department of Energy by the
Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Contents

Abbreviations and Acronyms

DCB	double-cantilever beam
SCC	stress corrosion cracking
SEM	scanning electron microscopy
SSR	slow strain rate
TTF	total time to failure

1. Summary

Susceptibility to stress corrosion cracking (SCC) of two candidate alloys for the inner container of the multibarrier nuclear waste package was evaluated by using wedge-loaded, precracked, double-cantilever-beam (DCB) specimens and the slow-strain–rate (SSR) test technique. Materials tested included Alloy C-22 and Ti Gr-12. A deaerated 90°C acidic brine (pH ≈ 2.70) containing 5 weight percent NaCl was used as the test environment. Both DCB and SSR tensile specimens were machined from mill-annealed plate materials. No additional thermal treatments were given to these specimens prior to their being exposed to the test solution. The DCB testing was performed for periods ranging from one through eight months. The initial and final stress intensity factor (K_I and K_f) values were calculated using a standard fracture-mechanics equation. Fractographic evaluation of the broken DCB specimens was performed by using scanning electron microscopy (SEM) to analyze the characteristics of failures.

During SSR testing, a strain rate of 3.3×10^{-6} sec^{-1} was used. Before being tested in the acidic brine, tensile specimens of each alloy were pulled in the test chamber in the dry condition at room temperature. Then, while in the test solution, the specimens were strained under different controlled electrochemical potentials. The controlled potentials (E_{cont}) were selected based on the corrosion potential measured in the test solution before the specimens were strained. The load versus displacement curve for each specimen was recorded. Ductility parameters such as the percent elongation (%El), the percent reduction in area (%RA), the true fracture stress (σ_f), and the total time-to-failure (TTF) were determined. Finally, metallographic examination was performed to evaluate the primary fracture and the secondary cracking, if any, along the gage section of the broken tensile specimen.

Results of DCB testing indicate that compared to Ti Gr-12, Alloy C-22 exhibited higher cracking susceptibility in terms of average crack growth. Further, cracking in both alloys might have been arrested after exposures of four to five months because no significant crack extensions were observed beyond this test duration. Fractographic evaluation by SEM revealed three distinct regions showing the characteristics of fatigue precrack (striations), SCC (transgranular brittle failure), and fast fracture (dimples).

The results of SSR testing indicate that the ductility of Ti Gr-12 in terms of σ_f and %RA was gradually reduced with more cathodic (negative) E_{cont} values. The secondary cracking along the gage section of all potentiostatically polarized Ti Gr-12 specimens was transgranular, confirming observations by other investigators. The primary fracture face showed the characteristics of a brittle failure. With regard to SCC behavior, Alloy C-22 was immune to cracking under environmental conditions used in a limited number of experiments performed so far.